GEORGIA INSTITUTE OF TECHNOLOGY
A. FRENCH TEXTILE SCHOOL
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FINAL REPORT

PROJECT B - 1304

DEVELOPMENT OF PRODUCTION TEST PROCEDURES USING AN EXPERIMENTAL TEST BUNDLE

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Table of Contents

LIST OF TABLES

LIST OF TABLES Contd.

LIST OF FIGURES

ABSTRACT

This project evaluated a test bundle which consisted of two pieces. This test bundle was designed to provide a quality control check on commercial laundering. The information gained from the test bundle would tell the commercial operator whether his operations were excessive, not good enough or normal for the type of material being washed.

A tensile test fabric was developed which would react uniformly to the various formulations which are used in the commercial laundry industry. The tensile strength losses for this fabric are higher than those of the old test fabric but the coefficient of variation is lower for the new fabric.

A test bundle program with the new tensile fabric and radioactive soil was implemented. This program provided information on the test bundles' performance in the linen industry and in the industrial rental garment industry. The results show that the test bundle is a reasonable test vehicle for quality control checks.

The objective of the project was to set up a test bundle procedure and methods of analysis for the test bundles. In cooperation with Mr. L. F. Luechauer of Steiner American Company, the test bundle would include devices to test the effects of heat, bleach, alkali, whiteness, mechanical wear, effectiveness of oil and stain removal, tensile strength, and, hopefully, provide an indication of the life of the fabrics with which the device was being used.

I. EXPERIMENTAL

The work began with a literature survey of fluidity measurements as a means of evaluating degradation of cotton fabrics. Various techniques were found which were used by many researchers to prepare the solvent. The most popular method was dissolve the cotton specimen in cupriethylenediamine solvent. The method published in the ASTM D-539-53 was tried at Georgia Tech. Two major problems arose with the usage of the Fluidity test. The first problem was incomplete liquefaction of the cotton. The second problem was the presence of oxygen in the system.

One solution to the first problem was to mill the cotton. Milling the cotton creates degradation on the order of that which is to be measured. A second solution was to admit oxygen to the nitrogen saturated system. The presence of oxygen caused the cotton to dissolve. However, the result was the same as milling. This solution became the second problem.

Work by various workers indicated that fluidity measurements and tensile strength losses were linearily related. Tensile strength measurements do not have the problems of fluidity measurements. Fluidity measurements required times of 12-24 hours to satisfactorily dissolve and make the measurement. Tensile strength measurement times are on the order of minutes (after 4 hours conditioning).

A. Tensile Tests of I.I.L. Test Fabric

While the fluidity tests were being conducted, a comparison was made of tensile test results obtained on two different types of instruments. The Instron Tester is an electronic instrument which records permanently and accurately both elongation and breaking load. Furthermore, the Instron tester requires only one calibration for a series of tests. The Scott Tester records the load and elongation through a mechanical linkage. The operators found it necessary to make a new calibration on the Scott tester after every set of strips were broken. The Scott tester usually requires a new sheet of chart paper after every two or three tests, while the Instron can be set to advance the chart after each test, thus requiring no attention from the operator.

A test was designed to evaluate the Instron and the Scott testers for reproducibility and ease of operation. A muslin fabric was conditioned at 65% relative humidity at 70°F., for 24 hours.

The total time required to prepare 18 specimens of unbleached muslin fabric was 50 minutes, or 2.8 minutes per specimen. These times did not change when the same number of bleached fabric specimens were prepared and tested on the Scott tester. The total time required to test 18 specimens of both fabrics on the Instron was 20 minutes each, or 1.1 minutes per specimen.

Table I shows the results of the test on both the unbleached fabric and the bleached fabric and both the Instron and the Scott testers.

Table I Comparison of Instron and Scott Tester on Unbleached Muslin and Bleached Fabric

	Unbleached Muslin		Bleached Fabric	
Sample	Instron	Scott Tester	Instron	Scott Tester
1	X	44.0	X	43.5
2	39.8	43.9	39.3	43.4
3	37.5	45.4	36.5	37.0
4	37.9	49.1	34.1	37.5
5	39.3	44.0	35.5	43.0
6	38.4	X	37.5	37.0
7	38.9	45.0	34.5	33.0
8	40.5	45.8	37.0	39.3
9	38.0	42.2	32.7	41.0
10	38.3	38.0	39.5	41.9
11	39.0	41.8	36.0	39.7
12	39.4	38.5	36.0	39.4
13	39.3	45.4	36.1	40.2
14	38.7	43.3	33.6	38.5
15	38.1	46.3	31.6	37.7
16	39.3	45.2	33.8	38.5
17	41.9	47.0	34.6	38.0
18	38.1	45.5	36.8	41.4
19	no test	no test	35.1	45.0
20	no test	no test	42.7	44.0
Total	662.0 lbs.	750.4 lbs.	682.7 lbs.	799.0 lbs.
Average	39.0 lbs.	44.1 lbs.	35.9 lbs.	40.0 lbs.
% C. V.	1.68	6.23	7.00	7.26

Table II Comparison of Results Obtained on the Instron and The Scott Tester on the I. I. L. Test Fabric

	Sized Test Fabric		Desized Test Fabric	
Sample	Instron	Scott Tester	Instron	Scott Tester
1	X	75.0	52.3	55.0
2	57.0	X	46.5	61.5
3	65.5	70.0	55.2	64.8
4	68.1	65.5	59.9	63.9
5	63.6	67.6	56.5	67.6
6	62.1	68.8	62.0	57.6
7	63.5	69.5	60.2	57.2
8	65.5	68.0	57.8	63.8
9	60.7	69.2	60.5	55.5
10	62.6	65.8	50.0	67.6
Total	568.6 lbs.	614.9 lbs.	560.9 lbs.	614.5 lbs.
Average	63.2 lbs.	68.3 lbs.	56.1 lbs.	61.5 lbs.
% C.V.	3.70	3.30	8.38	6.20

After testing the two fabrics on the Instron and Scott Tester, the I.I.L., test fabrics furnished by Mr. F. L. Luechauer were tested in the same manner. These fabrics were produced by Philadelphia College of Textiles. One had been desized by Mr. Luechauer. The other had not been desized. Mr. Luechauer had found that upon desizing the test fabric, a 10% reduction in the strength was noted. Mr. Luechauer requested that the Georgia Tech research group, as an independent group, test the sized and desized test fabrics.

As may be seen in Table II, a 10% reduction in strength was noted on the tests performed on the Scott Tester. A 11.2% reduction was noted when the same tests were performed on the Instron. Ten specimens were tested on both instruments. The Instron was selected as the test instrument for the project.

A 50 yard roll of the I.I.L., tensile test fabric was divided into three lots. One lot was placed in storage for later usage. A second lot was scoured and bleached. The test lots were randomly sectioned with all strips marked from the left side of the fabric to the right side. The randomly selected sections were ravelled and tested on the Instron. Table III shows the result of this study. Note: The Z test value located in columns labelled "Before" is a comparison of the before treatment and after treatment. The theoretical value of 2.09 should be used to compare the treatments. If the Z value is greater than 2.09 then scouring and bleaching caused a significant change in the tensile properties of the fabric. A value less than 2.09 indicates no significant change.

Table III
A Comparison of Warp Yarns Before and After Bleaching

Section	1		2		3		4		5		6	
Specimen	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1	65.9	60.8	69.4	42.2	60.0	69.9	70.0	52.9	64.0	--	68.0	49.3
2	64.0	54.6	59.7	58.0	65.8	65.5	59.1	59.9	60.0	--	63.1	53.9
3	60.4	63.0	60.2	46.5	63.0	67.4	65.5	51.5	58.1	--	--	61.5
4	66.2	63.1	65.2	53.0	61.5	68.9	48.2	61.0	59.1	--	55.0	56.7
5	51.0	57.0	68.2	42.4	53.9	--	64.5	54.3	57.9	--	54.0	52.1
6	62.5	50.8	64.5	44.2	47.7	64.3	67.0	28.2	55.3	--	68.1	40.1
7	65.1	42.2	64.2	44.8	61.2	66.0	50.6	54.9	60.4	--	63.0	46.8
8	55.5	44.9	63.7	65.8	58.0	53.3	56.0	44.0	56.0	--	64.2	52.2
9	66.1	40.3	--	63.6	51.5	58.1	64.0	44.1	56.9	--	67.8	29.0
10	60.9	50.3	95.0	52.0	57.5	65.2	--	65.2	64.4	--	58.0	63.6
11	66.0	51.0	68.6	33.9	33.5	62.2	54.2	43.5	62.1	--	65.4	47.0
12	--	63.1	68.1	39.3	39.5	60.8	65.2	60.0	53.4	--	65.0	44.5
13	61.5	47.0	60.5	57.0	55.5	64.2	68.4	61.2	64.2	--	59.5	65.3
14	65.9	59.9	62.0	59.0	40.0	52.0	59.0	57.2	48.8	--	65.1	58.1
15	68.3	58.3	69.2	55.0	49.1	66.4	65.5	63.6	64.1	--	69.3	64.3
16	64.0	61.2	66.0	60.1	36.0	66.0	63.0	33.5	45.1	--	68.1	58.1
17	62.0	36.0	68.0	38.9	38.0	47.0	61.9	48.5	63.9	--	68.8	36.3
18	66.9	46.9	60.9	49.0	42.0	68.9	61.9	53.5	49.0	--	59.1	61.0
19	72.1	51.1	69.5	42.9	58.5	68.1	67.7	55.3	58.5	--	65.3	58.1
20	64.0	39.5	58.1	35.2	56.8	68.5	65.5	59.0	51.2	--	68.9	42.6
Average	63.6	52.1	64.3	49.1	63.3	51.5	62.0	52.6	--	--	64.0	50.8
St'd Deviation	4.5	8.4	4.2	9.3	6.2	9.8	5.9	9.5	--	--	4.6	10.4
% C. V.	7.1	16.1	6.6	18.8	9.8	19.0	9.5	18.1	--	--	7.2	20.4
Strength Loss	18.2	--	23.5	--	18.7	--	15.2	--	--	--	20.6	--
Z	5.4	--	6.6	--	4.5	--	3.7	--	--	--	5.2	--

Table III (contd)

Section	7		8		9		10		11	
Specimen	Before	After	Before	After	Before	After	Before	After	Before	After
1	51.8	54.6	67.8	57.1	67.0	52.9	60.2	40.3	65.0	53.0
2	56.0	50.0	64.2	67.5	67.0	59.9	---	46.6	---	39.1
3	51.5	50.5	48.0	60.5	69.0	51.5	47.0	41.1	55.0	48.1
4	58.0	57.5	68.0	56.0	66.5	63.9	54.2	46.9	67.3	62.8
5	57.8	55.1	---	58.4	61.3	56.5	52.6	56.9	59.3	49.3
6	42.1	51.0	63.2	64.6	66.0	54.9	59.9	59.6	58.2	38.0
7	41.8	47.0	65.0	51.1	54.9	51.2	61.8	40.5	62.0	59.8
8	47.0	50.5	59.1	56.0	---	59.2	55.9	40.9	64.9	45.8
9	43.9	54.2	---	63.0	58.8	49.4	52.4	42.5	66.5	50.0
10	44.2	58.3	68.0	60.4	67.0	56.6	41.0	39.2	55.8	61.0
11	53.0	54.0	71.2	57.5	61.5	44.0	61.0	41.5	51.8	52.0
12	45.0	48.6	62.7	57.9	68.9	48.0	59.2	55.0	69.2	54.5
13	40.1	---	62.3	58.0	64.3	53.6	52.4	59.0	63.1	52.9
14	40.0	41.0	66.8	59.9	67.4	60.1	58.1	47.0	58.8	58.0
15	55.8	59.8	70.0	61.0	64.5	60.3	64.0	39.0	69.2	51.5
16	36.0	56.4	54.8	61.2	55.0	42.1	60.1	48.0	57.8	49.1
17	38.0	57.0	58.9	36.0	---	36.8	48.1	50.0	69.2	59.0
18	42.0	49.6	64.5	46.9	54.0	55.7	54.6	---	53.8	39.9
19	52.9	54.5	68.6	57.0	67.2	66.3	61.3	42.1	---	46.7
20	56.8	52.0	63.0	39.5	56.9	45.0	57.7	34.0	58.9	54.0
Average	52.7	47.7	63.8	56.5	63.2	53.4	55.9	45.8	61.4	51.2
St'd Deviation	4.4	7.0	5.4	7.6	5.0	7.4	5.8	7.2	5.5	6.9
% C. V.	8.4	14.8	8.6	13.4	7.9	13.8	10.3	15.6	8.9	13.5
Strength Loss	9.5	---	11.5	---	15.4	---	18.0	---	16.6	---
Z	2.7	---	3.5	---	4.8	---	4.8	---	5.1	---

Table III (Contd.)

Section	12		13		14		15		16	
Specimen	Before	After	Before	After	Before	After	Before	After	Before	After
1	65.0	64.0	67.4	50.8	65.2	63.8	67.8	59.2	66.1	57.1
2	58.0	56.8	62.5	61.0	--	59.8	63.1	47.8	58.8	47.9
3	57.0	58.5	--	63.5	65.7	55.0	69.7	56.1	57.0	66.4
4	60.9	57.8	65.5	61.5	64.1	62.2	66.3	60.5	70.0	62.9
5	--	63.4	68.2	61.5	69.1	64.9	64.2	55.0	60.7	61.1
6	65.0	58.0	55.2	42.0	66.2	46.2	60.0	35.6	62.5	52.5
7	67.0	56.3	59.0	58.9	63.5	62.1	--	45.1	52.8	43.2
8	62.0	55.3	68.2	38.8	67.1	52.8	65.0	53.0	63.9	59.7
9	66.1	35.4	38.0	37.1	59.0	57.5	65.3	61.0	67.9	54.0
10	66.3	57.0	61.0	64.9	63.9	62.8	67.1	55.6	63.0	53.6
11	66.5	47.0	--	36.2	61.4	65.2	--	42.9	63.1	56.9
12	55.3	67.0	57.5	55.5	65.0	52.0	57.2	55.0	68.0	30.5
13	66.3	58.0	68.0	55.8	60.9	51.5	64.0	55.0	--	67.0
14	69.1	37.5	62.8	56.8	69.1	59.0	60.5	64.1	69.2	34.2
15	64.4	50.0	65.9	62.9	61.0	58.5	67.1	57.9	71.0	61.1
16	65.0	53.5	50.1	59.5	55.4	49.8	64.3	37.8	60.1	42.0
17	71.0	28.0	63.0	48.0	62.6	55.8	58.5	52.0	69.4	36.1
18	68.0	44.0	63.5	40.5	71.9	56.8	55.5	37.2	54.0	63.0
19	64.2	63.3	72.0	57.9	--	66.1	65.6	59.3	69.7	57.4
20	66.0	60.3	62.7	50.0	66.0	57.0	60.0	56.9	61.1	50.7
Average	64.4	53.6	61.7	53.2	64.3	57.9	63.4	52.4	63.6	52.9
St'd Deviation	4.0	10.1	7.7	9.3	3.9	5.4	3.8	8.2	5.4	10.5
% C. V.	6.2	18.8	12.5	17.5	6.0	9.4	6.0	15.7	8.4	19.8
Strength Loss	16.8	--	13.8	--	9.9	--	17.4	--	16.9	--
Z	4.5	--	3.1	--	4.2	--	5.4	--	4.1	--

Table III (Contd.)

Section	17		18		19		20	
Specimen	Before	After	Before	After	Before	After	Before	After
1	67.5	58.6	69.9	46.3	58.0	57.8	61.0	53.0
2	65.5	42.6	55.0	50.2	47.0	55.0	46.0	51.2
3	71.0	--	66.3	56.5	51.0	43.2	--	52.2
4	64.0	62.1	68.2	56.8	54.3	46.0	54.2	52.9
5	--	58.3	54.8	60.7	54.5	61.5	53.5	50.3
6	58.1	--	65.0	64.0	58.0	56.9	--	51.8
7	66.9	49.2	63.3	60.1	52.0	50.6	56.9	44.1
8	63.2	60.1	--	47.2	39.0	40.5	48.5	55.9
9	--	61.5	64.0	56.0	54.2	44.7	52.0	38.0
10	67.0	60.0	66.6	55.2	56.1	42.7	52.0	49.3
11	66.5	53.8	65.2	45.0	56.7	51.0	54.1	51.1
12	68.9	57.0	--	41.5	52.5	56.9	53.0	51.0
13	65.9	59.0	60.2	47.2	56.2	45.9	60.5	55.6
14	65.2	54.5	62.2	58.5	58.9	34.5	56.5	55.1
15	63.5	59.0	68.2	36.4	--	33.0	60.0	54.0
16	69.0	49.1	56.5	53.5	59.2	29.0	60.1	43.1
17	63.0	44.0	31.4	62.9	58.5	--	62.7	50.0
18	65.5	35.0	64.0	53.9	60.0	53.3	50.0	42.0
19	67.8	64.1	70.4	59.1	50.3	43.5	60.2	48.7
20	--	49.1	69.1	37.0	57.7	--	57.0	39.9
Average	65.8	54.3	62.2	52.4	54.4	47.0	35.4	46.7
St'd Deviation	2.9	7.7	8.8	8.0	5.0	8.9	4.7	12.4
% C. V.	4.4	14.1	14.2	15.3	9.1	18.9	8.5	26.5
Strength Loss	17.6	--	15.8	--	13.6	--	15.7	--
Z	6.0	--	3.6	--	3.1	--	2.4	--

As can be seen from Table III, the tensile test fabric after scouring and bleaching had high % CV and % tensile loss values. This indicated that the fabric was unreliable for the job required.

After contacting the weaver of the test fabric and the yarn manufacturer for the past histories of the manufacturing processes and specifications, a search was begun to find a yarn manufacturer who would produce 800 pounds of yarn according to the specifications of the research staff at Georgia Tech. All those contacted indicated they could not handle such a small order. All yarn manufacturing plants have been operating at maximum capacity to satisfy their large customers. As a result, the A French Textile School processed the required cotton and produced the yarn and two types of fabric. The data for the yarns and fabrics are given in Table IV and Table V respectively.

Approximately, one month after testing of the Georgia Tech fabric, Coats and Clark Inc., indicated that a thread produced by their company had the same properties as the Georgia Tech yarn. This yarn is sold under their tradename of Anvil. Sample cones of unbleached and bleached were obtained from Coats & Clark.

A portion of the two treatments were scoured and tested on the Instron. Table VI summarizes the results of this study.

TABLE IV

Georgia Tech Yarn

Type of Fiber	California Cotton
Staple Length (inches)	1-1/4
Fiber Analysis	
Pressley (zero gauge)	91,130 PSI
Micronaire (fineness)	3.94
Fibergraph (fiber length distribution)	1.37 inches
% Short Fibers Removed	17
Count (cotton system)	40/2
Average Breaking Strength (pounds)	13.8
Coefficient of Variation (%C.V.)	5.9
Evenness Test %C.V.)	10.3

Table V

Georgia Tech Fabrics

Cone No.	Plain Weave (40 x 44)						Twill Weave (60 x 40)					
	Before		After		Strength loss	Z Test	Before		After		Strength Loss	Z Test
	Avg.	% CV	Avg.	% CV			Avg.	% CV	Avg.	% CV		
1	62.5	8.6	55.0	7.9	10.7	3.6	86.3	9.6	84.2	9.6	2.4	0.6
2	60.3	4.2	58.7	6.5	2.8	1.4	87.9	3.2	80.6	9.2	8.4	3.0
3	58.1	4.9	53.2	6.0	8.4	4.3	76.9	10.7	70.7	14.6	8.0	1.5
4	59.6	3.2	57.6	3.6	3.3	2.7	88.9	1.8	80.0	11.3	10.0	3.5
5	56.7	6.9	55.8	5.9	1.6	0.6	78.7	4.4	81.2	7.3	-3.2	1.1
6	55.7	4.1	55.4	4.4	0.5	0.3	78.7	8.2	70.7	10.5	10.1	3.0
Total Avg.	58.8	5.3	56.1	5.7	4.6	2.3	82.9	6.3	77.9	10.4	6.0	2.1

Table VI

Physical Properties of Unbleached and Bleached Anvil Test Thread
Before and After Alkali Scour

	UNBLEACHED		BLEACHED	
	Before	After	Before	After
Average Breaking Strength	1.76 lbs.	1.82 lbs.	1.90 lbs.	1.90 lbs.
Standard Deviation	0.073	0.29	0.40	0.12
Coefficient of Variation	4.1%	15.9%	7.4%	6.3%

The data indicates that bleached yarn was more uniform than the unbleached yarn. The decision to use the bleached yarn was based on the uniformity of the bleached yarn.

A twill type was originally selected as the fabric construction. The necessary poundage of yarn to produce 350 yards of this fabric (52" x 48") was calculated to be 132 pounds. A conference with Mr. Luechauer of Steiner American Corporation indicated that the design of the original test fabric was satisfactory. The construction of this fabric is shown in Table VII.

One hundred and thirty two (132) pounds of 38/2 ply Anvil was shipped to Prodesco, Inc., of Perkasie, Pennsylvania for the production of the fabric. A ten yard weave-out was requested before the completion of the 350 yard order.

The requested amount was received at Georgia Tech in January 1969. The fabric was divided into two portions for testing. One portion was scoured while the other was simply tested as required. Table VIII shows the results at the "Before Scouring" of randomly selected strips, from the left and right sides of the fabric. Table IX shows the results of scouring.

Table VII Construction of Original Tensile Fabric

Construction of Original Tensile Fabric	
Picks/inch	49
Ends/inch	52
Weave	Plain
Warp Report	80 ends (between dyed yarns)
Filling Report	2 picks

Table VIII

Prodesco's Weave-Out of Tensile Test Fabric - Before Scouring

	Left Side (lbs)	Right Side (lbs.)
	1. 71.8	69.0
	2. 69.0	69.0
	3. 73.0	73.2
	4. 72.5	68.7
	5. 73.6	77.6
	6. 64.5	75.6
	7. 75.0	77.8
	8. 80.5	65.0
	9. 72.8	71.8
	10. 78.6	75.3
	11. 64.5	74.2
	12. 68.0	61.0
	13. 69.4	71.7
	14. 66.3	82.5
	15. 53.0	73.0
	16. 71.0	71.0
	17. 75.4	75.0
	18. 77.0	70.8
	19. 69.5	71.8
	20. 75.2	60.6
	21. 71.4	78.8
	22. 74.3	65.4
	23. 70.5	66.0
	24. 79.2	73.0
	25. 79.0	70.6
	26. 75.5	68.0
	27. 76.0	63.2
	28. X	60.4
	29. X	58.5
	30. X	X
Total	1946.6 lbs.	2038.0 lbs.
Average	72.1 lbs.	70.3 lbs.
St. Dev	5.6 lbs.	5.9 lbs.
% C.V.	7.8%	8.4%

Overall (Before)

Total	3983.6 lbs.
Average	71.1
St. Dev.	5.8
% C.V.	8.2

Table IX

Prodesco's Weave-Out of Tensile Test Fabric-After Scouring

	Left Side	Right Side
	70.3	68.2
	69.9	71.2
	62.2	67.5
	73.4	63.2
	65.0	69.0
	70.1	61.8
	73.0	70.0
	69.1	74.6
	67.5	61.0
	74.6	64.8
Total	695.1 lbs.	671.3 lbs.
Average	69.5	67.1
St.Dev.	3.64	4.2
% C.V.	5.2%	6.2%

Overall (After)

Total	1366.4lbs.	% diff=3.9
Average	68.3	
St. Dev.	4.1	
% C.V.	6.0	

The coefficients of variation indicate that the strips from before and after scouring are uniform. Based upon this information, the fabric was accepted.

B. Local Test Program

After the fabric for the tensile test had been accepted and the final yardage shipped to Georgia Tech, sections were attached to Five-wash Testor units and sent to the participants in the Atlanta area for laundering. Appendix A shows a list of those participants in The Atlanta Test. Two were linen rental plants while the third was a industrial garment firm. Appendix B shows the instruction sheet that attached with each test bundle. (Note: a test bundle incorporates a one-wash Testor and is Five-wash Testor.)

The purpose of the Atlanta test was to locate and remedy any problems that might hinder the national test.

The linen plants were instructed to wash three test bundles. These bundles were processed with three different soil formulations. The industrial plant processed two formulations.

An evaluation of the test bundles was made and Tables X through XVII give the results of these analyses.

Table X Evaluation of Testors (Atlanta Test)

Plant Type: Linen

Soil Classification: Light Soil

Washing Factors:

	One wash	Five wash
Bleaching intensity	OK but low	Too high
Bleaching pH	OK but low	Too high
Heat effects	OK but low	--------
Alkali effects	OK but low	OK but low
Fatty soil removal	OK but high	OK but high
Mechanical Action	OK but high	OK
Oily Stain	OK but low	OK but low
Whiteness (visual)	OK	OK
% Tensile loss	---------	9.4

Table XI Evaluation of Testors (Atlanta Test)

Plant Type: Linen

Soil Classification: Heavy Soil

Washing Factors:

	One wash	Five wash
Bleaching intensity	Too low	OK but low
Bleaching pH	Too low	OK but low
Heat effects	Too low	----------
Alkali effects	OK but low	OK but low
Fatty soil removal	OK	OK
Mechanical Action	OK	OK
Oily Stain	OK but low	OK
Whiteness (visual)	OK	OK
% Tensile loss	----------	28.7

Table XII Evaluation of Testors (Atlanta Test)

Plant Type: Industrial

Soil Classification: White formula

Washing Factors:

	One wash	Five wash
Bleaching intensity	OK but high	OK but high
Bleaching pH	OK but high	OK but high
Heat effects	OK	-----------
Alkali effects	OK	Too high
Fatty soil removal	OK but high	OK but high
Mechanical Action	OK	OK
Oily stain	OK	OK
Whiteness (visual)	OK	OK
% Tensile loss	---------	19.8

Table XIII Evaluation of Testors (Atlanta test)

Plant Type: Industrial

Soil Classification: Colored Formula

Washing Factors:

	One wash	Five wash
Bleaching intensity	---------	---------
Bleaching pH	--------	---------
Heat effects	Too low	---------
Alkali effects	Too high	Too high
Fatty soil removal	Too high	OK
Mechanical action	OK but high	OK but high
Oily Stain	Too low	OK but low
Whiteness (visual)	OK	OK
% Tensile loss	---------	11.4

Table XIV Evaluation of Testors (Atlanta Test)

Plant Type: Linen

Soil Classification: Medium soil

Washing Factors:

	One wash	Five wash
Bleaching intensity	Too Low	OK but low
Bleaching pH	Too low	OK
Heat effects	OK	---------
Alkali effects	OK but high	OK
Fatty soil removal	OK	OK
Mechanical action	OK	OK
Oily Stain	OK but low	OK but low
Whiteness (visual)	OK	OK
% Tensile loss	---------	17.3

Table XV Evaluation of Testors (Atlanta Test)

Plant Type: Linen

Soil Classification: Heavy Soil

Washing Factors:

	One wash	Five wash
Bleaching intensity	OK	OK
Bleaching pH	OK	OK
Heat effects	---------	---------
Alkali effects	OK but low	OK
Fatty soil removal	OK	OK but high
Mechanical action	OK	OK
Oily stain	OK but low	OK but low
Whiteness (visual)	OK	OK
% Tensile loss	13.5	13.5

Table XVI Evaluation of Testors (Atlanta Test)

Plant Type: Linen

Soil Classification: Medium Soil

Washing Factors:

	One wash	Five wash
Bleaching intensity	OK but high	OK but high
Bleaching pH	OK	Too high
Heat effects	---------	---------
Alkali effects	Too low	OK but low
Fatty soil removal	OK	OK
Mechanical Action	OK	OK
Oily stain	OK	OK
Whiteness (visual)	OK	OK
% Tensile loss	---------	23.1

Table XVII Evaluation of Testors (Atlanta Test)

Plant Type: Linen

Soil Classification: Light soil

Washing Factors:

	One wash	Five wash
Bleaching intensity	OK	OK but high
Bleaching pH	OK but low	OK but high
Heat effects	---------	---------
Alkali effects	OK but low	OK
Fatty soil removal	OK	OK
Mechanical action	OK	OK
Oily stain	OK but low	OK
Whiteness (visual)	OK	OK
% Tensile loss	---------	16.9

C. National Test Program

Upon completion of the Atlanta tests, a meeting was held at Georgia Tech with members of the sponsors' research committee and Georgia Tech personnel to discuss the Atlanta test and to prepare for the national test program. Appendix B shows the instruction and report sheets used in the Atlanta test program. A major modification was made and Appendix C shows the instruction and report sheets sent out during the national program.

For the national program radioactive soil samples (containing carbon , oil and fat tagged with Carbon 14) were attached to both pieces of each test bundle. Appendix D lists the participants in the national program. (Originally, ten linen and ten industrial plants were selected to participate in both the Atlanta and the national tests; however, for various reasons only those shown in Appendix D were able to participate.)

A total of forty test bundles were shipped and thirty and one half were returned.

These test bundles were evaluated for the following factors: Bleaching intensity, bleaching pH, heat effects, alkali effects, fatty soil removal, mechanical action, oily stain removal, whiteness (instrumental), % tensile loss, % carbon loss, % fat removal, and % oil removal.
Appendix E gives the summary of each test bundle. (Note: industrial colored - was not evaluated for bleaching since no bleach was used. The test bundles are grouped according to the plant by which they were processed. No company names are shown.

II. Discussion

A. Measurement of Degradation

One of the purposes of this project was to find a suitable way to measure degradation of garments and other goods processed in a commercial laundry. Since replacement of rental garments is a large cost factor, a rental plant does not wish to accelerate the replacement by excessive degradation. As a means of analyzing the amount of degradation, fluidity was suggested at the start of the project.

The major disadvantage of fluidity measurements on cellulose is the inability to totally dissolve the specimen without causing some degradation as a result of the dissolving technique.

Linear relationships have been found between the measurement of tensile strength loss and fluidity. In the case of tensile strength loss measurements, one is measuring the forces between and within the polymer chains. The less degradation that has occurred, the greater these forces will be.

A second advantage is that tensile tests may be obtained at a faster rate than fluidity. The time difference in eight to twelve hours. Tensile tests require four hours for a sample to condition and thirty minutes to ravel and break ten specimens out of the sample. Fluidity takes at least sixteen hours to dissolve the cotton before fluidity measurements may be made. Furthermore, during the dissolving of the cotton specimens oxygen must be excluded from the system to prevent further degradation of the specimen. This is not a problem with tensile strength measurements.

B. Whiteness Evaluation

The definition of whiteness has undergone some drastic changes within the past several years. In the 1950's, whiteness was obtained by bluing; a technique designed to make the yellowness of a white fabric disappear. With the advent of the detergents which advertise "whiter than white", etc., the concept of whiteness has changed quite significantly from the 1950's definition. Along with these definition changes have been changes in the mathematical models used to describe whiteness. To date, not a single equation has been derived that adequately describes whiteness.

The formula that was selected for usage during this project was Dr. Eugene Allen's. This formula is as follows:

Whiteness Index = Xcie + Ycie + Zcie

Where: Xcie = the amount of red

Ycie = the amount of yellow

Zcie = the amount of blue.

Whiteness measurements were made on the backs of one wash testor units and on the toweling attached to five wash testor unit toweling which is a good scavenger of soil. The Color-Eye, Large Sphere model, was used to obtain the necessary colorimetric readings. The Color-Eye is capable of reproducing two standard light sources: Light source A (tungsten) and light source C (sunlight).

Light source C was used throughout the duration of the project. This allowed ultra-violet light to be radiated upon the sample and indicated the presence of any optical brightner.

In the whiteness index, if any optical brightner was present, the Zcie value would increase. Optical brightners absorb energy in the ultra-violet portion of the electromagentic spectrum and emit this energy in the visual. Generally, the energy is emitted in the blue region; although there are three common types of optical brightness. These are classified as follows: (1) violet, (2) blue, and (3) green. Although these three classes are named as colors they do not unite true violet or true green. These are merely the regions of the spectrum which they are nearest.

Dr. Allen's equation adds the three primary colors to obtain a measure of whiteness. A perfect white, not optically brightened, would produce a value of 300, while, a perfect black would be 0. Greys are usually located about 150. The presence of an optical brightner on a garment which was originally white; later, soiled and washed may produce a whiteness index less than 300. The Zcie value is significantly upholding the whiteness index; while, the Xcie and Ycie values may be low.

One should look at the changes in the X, Y, Z values for a true indication of the effect of an optical brightner.

The spectrum colors have been defined by a three dimensional color solid. Two dimensions are shown in Figure 1. The third dimensional is out of the place of the of the sheet. A dot, such as A, on the graph would indicate the location of some color. If X, Y, or Zcie values change due to some process, the dot's location will change. A line drawn between the dots will indicate the direction of the change.

Whiteness measurements were strictly subjective during the Atlanta Test. These measurements were made by an observer who determined that after laundering

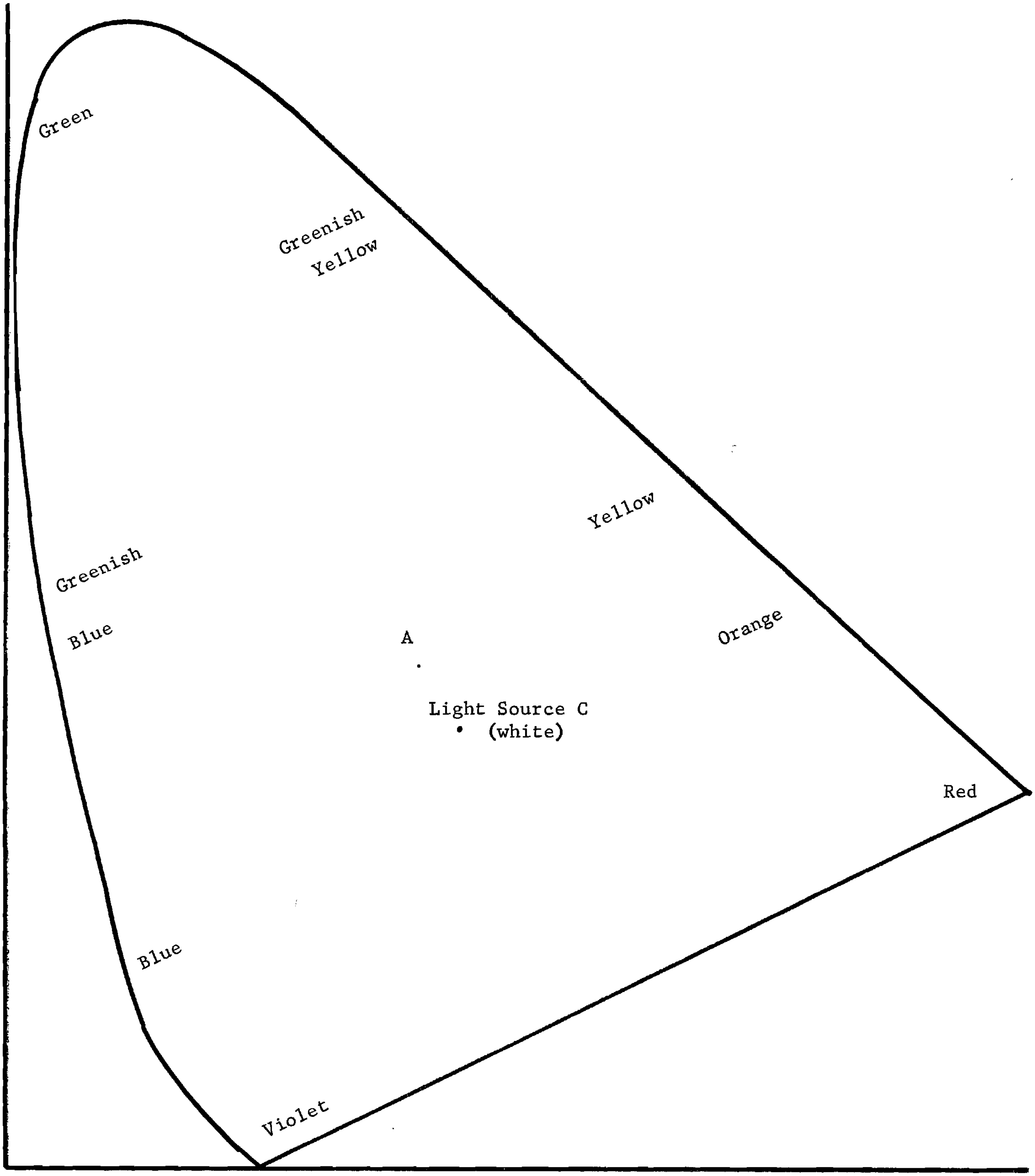

Figure 1 CIE Chromaticity Diagram

the whiteness was not good (too low); some soil redeposition - (OK but low); or good soil removal (OK).

During the national test program, the whiteness measurements were made instrumentally. Table XLVIII shows the X, Y, and Zcie values after processing. Whiteness information is not available on the industrial colored formula; although, CIE values are shown in the table. Whiteness indices would not be true on the colored formula since the presence of large concentrations of colored matter represents a significant deviation from the concept of whiteness.

One result of an attempt to produce a white material is that the material can be too white. The implication is that to produce a good white might result in extreme degradation to the material by the necessary scouring and bleaching.

C. Tensile Tests

As mentioned in the chapter on experimental work, the Instron tester was used instead of the Scott tester, throughout the project to measure tensile strength. This instrument is easier to operate and produces more uniform data than mechanical type testers.

The tensile strength losses reported in the Atlanta Tests, the National Tests, and the Steiner American Tests indicate that the tensile test fabric is sensitive to certain changes during the first wash. However, one must note that while significantly high strength, losses are reported, the fabric acts uniformily.

Table XVIII CIE Values For One and Five Wash Test Pieces

Test Bundle 1

	One Wash	Five Wash
X	79.7	75.3
Y	80.5	75.1
Z	100.6	96.4

Test Bundle 2

One Wash	Five Wash
75.6	74.6
74.6	73.2
69.8	67.2

Test Bundle 4

	One Wash	Five Wash
X	75.9	76.9
Y	76.7	77.8
Z	97.4	96.9

Test Bundle 7

One Wash	Five Wash
78.3	73.8
79.7	74.1
97.9	94.4

Test Bundle 8

	One Wash	Five Wash
X	68.0	64.4
Y	68.5	65.3
Z	83.4	79.6

Test Bundle 11

One Wash	Five Wash
78.9	75.3
80.1	75.7
97.2	96.3

Test Bundle 13

	One Wash	Five Wash
X	78.7	78.0
Y	80.1	78.5
Z	97.8	103.7

Test Bundle 15

One Wash	Five Wash
77.7	72.5
79.0	73.3
94.0	90.3

Test Bundle 19

	One Wash	Five Wash
X	76.1	79.5
Y	78.1	79.8
Z	95.1	104.4

Test Bundle 21

One Wash	Five Wash
79.8	76.6
80.8	76.8
99.6	101.1

Test Bundle 22

	One Wash	Five Wash
X	78.9	75.0
Y	79.7	75.4
Z	98.7	99.0

Test Bundle 23

One Wash	Five Wash
78.5	76.7
79.9	77.6
95.7	96.0

Table XVIII Contd.

Test Bundle 24

	One Wash	Five Wash
X	71.9	77.6
Y	78.9	78.2
Z	99.2	98.2

Test Bundle 25

One Wash	Five Wash
74.9	78.6
76.5	79.1
91.4	99.1

Test Bundle 28

	One Wash	Five Wash
X	79.2	76.8
Y	80.2	77.7
Z	100.5	98.9

Test Bundle 29

One Wash	Five Wash
80.0	75.9
81.3	76.6
99.2	96.4

Test Bundle 34

	One Wash	Five Wash
X	76.0	78.4
Y	78.0	79.6
Z	93.1	99.7

Test Bundle 35

One Wash	Five Wash
77.9	76.9
79.2	77.9
97.3	97.2

Test Bundle 36

	One Wash	Five Wash
X	77.8	78.7
Y	78.9	80.2
Z	97.6	99.4

Test Bundle 40

One Wash	Five Wash
82.7	76.5
83.5	77.4
103.6	96.7

Test Bundle 41

	One Wash	Five Wash
X	77.2	76.7
Y	78.1	78.6
Z	95.7	95.3

Test Bundle 42

One Wash	Five Wash
79.1	78.8
75.8	79.9
94.7	97.4

One reason for the fabric's behavior may be due to certain chemical agents which may have been added to the yarn to increase the yarn's strength during yarn manufacture. These agents usually wash out quite readily in the presence of alkali and soap. All indications are, at this point, that the fabric should be washed with hot water and soap or given a standard desize treatment before using as a tensile test fabric. This treatment would reduce the high strength losses yet not change the fabric's capability to react uniformily to further chemical treatments such as alkali.

Both the Atlanta and the National tests show good correlation with respect to tensile strength losses and the wool fabric attached to the test bundle.

D. Evaluation of Test Bundles

All test bundles were evaluated by subjective techniques. This technique is based on a visual examination of the test pieces and the conditions under which they were processed. A test bundle that was processed by an industrial plant using a white formula would not be expected to meet the same criteria as one that had been processed in a linen plant under the heavy soil classification.

The descriptors that were used in the evaluation of the test bundles are as follows: Too low; OK but low: OK; OK but high; Too high. This range of description allows for the normal case (OK); slight deviations from the normal case (OK but low and OK but high)and extremes deviations (Too low and Too high).

Table XLIX shows the numbers of the test bundles that were shipped to each participant. As mentioned earlier, linen plants received three test bundles while the industrial plants received two test bundles.

Tables L through LXI show the frequency distributions of the various tests according to soil classifications, one wash and five wash test pieces. Colored formulas were not analyzed for bleaching pH and bleaching intensity since these formulas did not include bleach.

The frequency analyses for each of the factors; such as bleaching intensity, etc., show that the materials were subjected to extreme chemical conditions. Where bleach was used the test bundles indicated that too much bleach was used. The same is true with the usage of alkali. A trend was noted in analyzing of one wash and five wash test pieces of the test bundles. This trend indicated that the treatments increased in severity through a cumulative effect or through one of the five washes being exceptional severe. There were cases in which the opposite situation was found; however, these cases were unusual in the respect of not being processed five times (in one case) or in not following the formulation given.

A correlation study was attempted between the visual oily stain removal and the redioactive carbon oil stain, but no correlation was found. Many visual values that were labeled as OK had corresponding oil stain radioactive values lower than those associated with OK but low values.

Table XIX Plant Numbers and Corresponding Test Bundles

Plant Number	Test Bundles
1	12, 13
2	14, 15
3	10, 11
4	8, 9
5	6, 7
6	1, 20
7	2, 3
8	4, 5
9	23, 24, 25
10	19, 21, 22
11	34, 35, 36
12	28, 29, 30
13	40, 41, 42

Table XX Frequency-Analyses of Industrial Heat Effects

Soil Classification: White Formula

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	2	2	4

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	0	2	6

Soil Classification: Colored Formula

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	1	2	3	2

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	0	3	5

Table XXI Frequency-Analyses of Industrial Alkali Effects

Soil Classification: White Formula

One Wash

Too low	OK but low	OK	OK but high	Too high
0	0	4	1	3

Five Wash

To low	OK but low	OK	OK but high	Too high
0	0	3	2	3

Soil Classification: Colored Formula

One Wash

Too low	OK but low	OK	OK but high	Too high
0	1	2	1	4

Five Wash

Too low	OK but low	OK	OK but high	Too high
0	0	1	3	4

Table XXII Frequency-Analyses of Industrial Fatty Soil Removal

Soil Classification: White Formula

One Wash

Too low	OK but low	OK	OK but high	Too high
0	0	1	4	3

Five Wash

Too low	OK but low	OK	OK but high	Too high
0	0	0	1	7

Soil Classification: Colored Formula

One Wash

Too low	OK but low	OK	OK but high	Too high
0	0	4	4	0

Five Wash

Too low	OK but low	OK	OK but high	Too high
0	0	0	6	2

Table XXIII Frequency-Analyses of Industrial Mechanical Action

Soil Classification: White Formula

One Wash

Too low	OK but low	OK	OK but high	Too high
0	1	7	0	0

Five Wash

Too low	OK but low	OK	OK but high	Too high
0	1	5	1	1

Soil Classification: Colored Formula

One Wash

Too low	OK but low	OK	OK but high	Too high
1	1	5	1	0

Five Wash

Too low	OK but low	OK	OK but high	Too high
0	1	4	2	1

Table XXIV Frequency-Analyses of Industrial Stain Removal

Soil Classification: White Formula

One Wash

Too low	OK but low	OK	OK but high	Too high
0	4	4	0	0

Five Wash

Too low	OK but low	OK	OK but high	Too high
0	1	7	0	0

Soil Classification: Colored Formula

One Wash

Too low	OK but low	OK	OK but high	Too high
1	3	4	0	0

Five Wash

Too low	OK but low	OK	OK but high	Too high
1	1	6	0	0

Table XXV Frequency Analyses of Linen Bleaching Intensity

Soil Classification: Light Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
1	0	1	0	3

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	1	0	4

Soil Classification: Medium Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	1	1	2	1

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	1	2	2

Soil Classification: Heavy Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	1	2	1	0

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	2	1	1

Table XXVI Frequency Analyses of Linen Bleaching pH

Soil Classification: Light Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	1	2	1	0

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	1	0	2	1

Soil Classification: Medium Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	1	2	1	1

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	0	1	4

Soil Classification: Heavy Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	3	1	1

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	2	1	2

Table XXVII Frequency Analyses of Linen Heat Effects

Soil Classification: Light Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	1	2	0	1

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	2	1	1

Soil Classification: Medium Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	2	1	2

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	0	1	4

Soil Classification: Heavy Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	1	1	2	1

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	1	1	0	3

Table XXVIII Frequency-Analyses of Linen Alkali Effects

Soil Classification: Light Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
1	1	2	0	0

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
1	0	3	0	0

Soil Classification: Medium Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
1	0	2	0	2

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	2	0	3

Soil Classification: Heavy Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	5	0	0

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	0	1	4

Table XXIX Frequency Analyses of Linen Fatty Soil Removal

Soil Classification: Light Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
1	1	2	0	0

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
1	0	2	0	1

Soil Classification: Medium Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	2	1	2

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	1	1	3

Soil Classification: Heavy Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	1	3	1

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	0	1	4

Table XXX Frequency Analyses of Linen Mechanical Action

Soil Classification: Light Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	4	0	0

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	4	0	0

Soil Classification: Medium Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	5	0	0

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	5	0	0

Soil Classification: Heavy Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
1	2	1	1	0

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	4	1	0

Table XXXI Frequency-Analyses of Linen Oily Stain Removal

Soil Classification: Light Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	1	2	0	1

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	3	0	1

Soil Classification: Medium Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	3	1	1

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	0	3	1	1

Soil Classification: Heavy Soil

One Wash

Too Low	OK But Low	OK	OK But High	Too High
1	0	4	0	0

Five Wash

Too Low	OK But Low	OK	OK But High	Too High
0	1	4	0	0

E. Control Tests (Steiner American)

Mr. Louis Luechauer of the Steiner American Corporation agreed to perform control tests on the tensile test fabric. These tests were performed using different washing formulations with the test pieces inside and outside of a net. Any correlation with the national tests must be made on those pieces outside of the net. These test pieces were labeled J-L series. (OK) Table LXIII shows the results of the tests.

The J-L-2 test piece may be compared with the colored formula used in the national test. J-L-3 may be compared with the white formula J-L-4 and J-L-5 may be compared with the medium soil and heavy soil classifications, respectively. Table LXIV shows the compared between these control tests and the data indicates a discrepancy in all of the tests. Mr. Luechauer indicated that some of his tests were designed to be extreme cases. This may account for such high values. Of note is the indication that one of the test bundles used in the Colored Formula was not washed five times.

The loss for this test bundle was 5%. Other indicators were the lack of color removal on the red wool swatch and the lack of any significant increase in the average % loss for the colored formula.

Not too much confidence may be placed on any comparison of the Steiner American control tests if a one-to-one comparison is being made. But if a check on extreme capabilities is being made then the Steiner American tests are of great value.

The coefficients of variation for the Steiner American test are similar in nature to those in the national test program. The Steiner American test showed uniform coefficients of variation even through the strength losses were high.

Table XXXII Steiner American Control Test Formulations

Series	
J-L-1	Colored Table Linen
J-L-2	Colored Coveralls
J-L-3	White Coveralls
J-L-4	Turkish Towels
J-L-5	Kitchen and Bar Towels
J-L-6	Dehaired Bar Towels
J-L-7	Stain Treatment

Table XXXIII

Tensile Strength Measurements on J-L Series

Specimen	J-L-1A(lbs.)	J-L-1B(lbs.)	J-L-2A (lbs.)	J-L-2B(lbs.)	J-L-3A(lbs.)	J-L-3B (lbs.)
1	54.6	58.8	60.0	60.4	47.2	51.7
2	65.5	58.3	55.2	56.1	47.9	49.3
3	59.0	56.8	55.0	65.6	43.0	59.0
4	59.8	52.2	53.8	59.8	53.0	35.6
5	59.5	60.0	45.0	61.5	48.6	45.0
6	60.7	64.3	59.0	56.0	40.0	51.6
7	61.3	65.7	47.8	63.6	47.6	43.2
8	61.3	59.3	49.4	64.0	47.2	40.0
9	57.8	65.0	56.8	64.9	51.9	50.0
10	63.2	69.9	60.6	66.3	49.5	59.8
Total	603.0	610.0	543.0	118.0	475.9	481.2
Average	60.3	61.0	54.3	61.8	47.6	48.1
St.Dev.	2.8	4.9	5.0	3.5	3.6	6.8
% C.V.	4.7	8.0	9.3	5.7	7.6	14.2
% Loss	15.2	14.2	23.6	13.1	31.9	32.3

Table XXXIII Contd.

Specimen	J-L-4A(lbs)	J-L-4B(lbs.)	J-L-5A(lbs.)	J-L-5B(lbs.)	J-L-6A(lbs.)	J-L-6B(lbs.)	J-L-7A(lbs.)	J-L-7B(lbs.)
1	51.8	63.5	53.9	50.6	56.0	62.3	43.0	38.9
2	64.2	44.5	36.1	46.6	61.3	55.8	45.8	42.9
3	59.0	63.0	44.0	51.8	45.0	58.0	46.7	46.2
4	60.1	57.1	60.0	55.4	X	60.1	41.2	48.9
5	51.0	57.8	44.8	63.7	64.2	58.6	39.4	42.3
6	64.5	51.5	51.9	61.9	52.0	57.7	36.9	43.4
7	59.5	54.8	44.2	54.2	56.2	55.6	41.5	41.6
8	67.1	59.0	56.0	59.6	62.1	59.8	39.3	39.5
9	67.7	64.0	48.4	50.0	59.3	56.0	45,5	44.0
10	52.5	84.5	54.6	59.8	60.1	53.6	45.3	45.2
Total	608.0	579.7	494.0	553.6	516.2	577.5	424.6	432.9
Average	60.8	58.0	49.4	55.4	57.4	57.8	42.5	43.3
St. Dev.	6.6	6.1	6.8	5.4	5.6	2.4	3.2	2.9
% C. V.	10.9	10.5	13.8	9.8	9.7	4.2	7.4	6.6
% Loss	14.5	18.4	30.5	22.1	19.3	18.8	40.3	39.1

Table XXXIV Comparison Between J-L Series and National Tests

J-L Test	% Loss	Averages of National Test	% Loss
J-L-2	13.1	Colored Formula	10.4
J-L-3	31.9	White Formula	17.0
J-L-4	14.5	Medium Soil	19.9
J-L-5	22.1	Heavy Soil	21.8

F. Time Analysis

Time studies were performed on the various operations of the make-up of the test bundles and evaluation of the test pieces.

The test bundle consists of a one wash Testor and a five wash Testor. The test pieces are identical in all respects; except, the five wash test piece includes a tensile test fabric. Radioactive soil was attached to both test pieces. The test pieces are assembled by Laundry Testor Lab of Salt Lake City, Utah.

Assembly by Georgia Tech personnel included attachment of tensile test fabric to the five wash test piece; radioactive soil to both pieces; and heat sensitive paper and cloth to both pieces. The fabric had to be cut into strips which were ten inches long and included 10 specimens per strip. The radioactive soil included carbon, oil, and fat specimens. These are also prepared by Laundry Testor Lab. The heat sensitive paper and cloth are available from the same source.

The breakdown for each operation is as follows:

1.	Attachments of tensile fabric, radioactive soil, heat sensitive paper and cloth, and mail preparation	13.5 minutes.
2.	Subjective evaluation with layout.	7.0 minutes.
3.	Whiteness evaluation or Color-Eye.	3.6 minutes.
4.	Tensile strength loss on Instron (includes ravelling and placement)	30.0 minutes.
5.	Soil evaluation (radioactive)	3.5 minutes.
6.	Calculation of tensile loss	1.0 minutes
	Total Time	58.6

Allowing for some operators mistakes such as not properly positioning a specimen in a jaw of the Instron, the total time to prepare and analyze one test bundle is one hour.

The cost of the operation would be as follows:

Personnel @$2.00 per hr. 1 bundle	$ 2.00
Overhead (100% of personnel)	2.00
Test Bundle (with radioactive soil attached)	4.25
Tensile test fabric	.75
Trailer (for easy identification)	.25
Total cost per bundle	$ 9.25

G. Equipment Requirements

The equipment used in this project was considered to be the minimal requirements for carrying out the project successfully.

Tensile tests were performed on an electronic tensile tester - The Instron model TT-C. (A smaller model would perform equally as well and be much cheaper. The table-top model sells for approximately $4,000.)

Whiteness measurements were made on the Color-Eye, Large Sphere, Model C. The cost of this instrument is approximately $10,000; however, it serves dual duty as spectrophotometer and a colorimeter. A smaller version is available for about $6,000 which will suit all requirements of the commercial laundry industry. Other optical instruments are available in the same price range, but at the time of this writing, only the Color-Eye and the Hunter-Lab Model D-40 are equipped to handle flourescent materials.

Radioactive soil analyses were performed on the Nuclear-Chicago, Mark I liquid scintillation system. This is a research instrument and the same results could have been achieved on the Beckman liquid scintillation system which is priced about $9,000.

All calculations, whiteness index, and tensile strength data were made on the Hewlett-Packard Calculator, Model 9100A. This is a programmable calculator which sells for $5,000. Another calculator of the same type has recently been introduced by Wang Laboratories, Inc. for the same price but with ten times the capacity of the Hewlett-Packard. This calculator is called the Wang 700. A calculator of this type is necessary to keep the direct labor costs down. If the calculations involved were made on a standard rotary calculator the time would be multiplied by a factor of ten.

III Conclusions

The test bundle is a suitable device to detect errors in processing commercial laundry and as a quality control device. The test bundle can indicate with a high degree of accuracy whether the formulation used with the test bundle was adequate or too stringent.

The tensile test fabric developed by Georgia Tech with the aid of the Steiner American Corporation, Prodesco, Inc., and Coats and Clark Co., is the best available at the present time. The high strength losses experienced initially may be reduced by washing before using. The fabric is quite uniform in responding to the various formulations used in the commercial laundry industry.

The radioactive soil analysis performs adequately. The technique is a standard type whereby the radioactive soil is counted before and after processing. The % count difference is an indicator of the amount of soil removed by the processing.

Whiteness indices have limited usefulness. The differences in the X, Y, and Z, CIE values provide much more information. The Z term indicates the presence of optical brightners while the Y term is related to the lightness of the specimen. A grey would have values from 50 - 80%. A Z term with a value higher than the Y term indicates optical brightner was probably used. The higher the Z term is the more optical brightner was used. If the X term is abnormally high while the Y term is low and the Z term is high then an excessive amount of optical brightner was used. To plot the data on a graph, the CIE terms are reduced to Cartesian coordinates by the following formulas:

$$X = \frac{Xcie}{Xcie + Ycie + Zcie}$$

$$Y = \frac{Xcie}{Xcie + Ycie + Zcie}$$

These coordinates locate any color in a uniform color space.

The cost per bundle may rise slightly since the salary of a lab director and cost of the building was not included in the $9.25 total.

IV. Recommendations

The test bundle as is should be accepted and used to evaluate the performance of the commercial laundry industry.

Whiteness indices should be used on a limited basis. Where possible, the CIE terms should be used.

The radioactive soil analysis should be used in place of oily stain or visual stain tests. The radioactive analysis allows a "number" to be tagged on a given formulation.

APPENDICES

APPENDIX A

Participants in Atlanta Test Program

Institute of Industrial Launderers

Gulf Uniform Rental

Linen Supply Association of America

Atlanta Linen Service

Silco Rental Services

APPENDIX B

ATLANTA PROCESSING INSTRUCTIONS

EXPERIMENTAL TEST BUNDLE PROGRAM

A number of test bundles (depending upon the number assigned to your plant) are enclosed with instructions in the test bundle bag. Each test bundle consists of a one-wash test piece and a five-wash test piece. Each test bundle is to be processed according to the classification(s) in the accompanying letter.

READ THESE INSTRUCTIONS COMPLETELY BEFORE PROCEEDING WITH PROCESSING!

The one-wash and five-wash test pieces have been premarked and care must be exercised accordingly.

A. Preparation and Marking

1. Using marking ink or a marking machine, place a description of the items washed next to the serial number on the test piece.

   Note: If a test bundle is laundered with shirts only, as an example mark the bundle "white shirt formula"; or if laundered with sheets mark the bundle "sheets and pillowcases".

2. Open the brown paper sack and remove the plastic packets of pink cloth and purple paper. Insert them into the unbleached cloth sack of the one wash test piece and sew or staple the cloth sack closed. Process the bundle immediately.

3. Do not wash any test piece in a net. Each test piece is flagged with a trailer.

B. Laundering Instructions for a One-Wash Test Piece

*1. Wash the one-wash test piece once.

2. While it is unnecessary to extract the test bundle following laundering, if extraction with the load is more convenient, the test bundle will not be affected.

3. DO NOT PRESS, IRON, OR TUMBLE-DRY. ALLOW TEST PIECE TO AIR-DRY. RETAIN FOR RETURN TO THE LABORATORY.

   Note: The test piece may be laid out on a clean towel; smooth out by hand to remove wrinkles. Avoid contact with dust, lint, or metal surfaces.

C. Laundering Instructions for Five-Wash Test Piece

*1. Wash the five-wash test piece five times.

Note: Place both cut off numbers and test piece in a plastic bag in a plastic bucket between washing cycles. Avoid contamination of the test piece or numbers with washroom supplies.

3. It is unnecessary to extract the test piece between washings. If extraction with the load is more convenient, this will not affect the test piece.

* The one-wash test piece and five-wash test piece must be washed in the same classification.

4. DO NOT PRESS, IRON, OR TUMBLE-DRY. ALLOW TEST PIECE TO AIR-DRY. RETAIN FOR RETURN TO THE LABORATORY.

Note: The test piece may be laid out on a clean towel; smooth out by hand to remove wrinkles. Avoid contact with dust, lint or metallic surfaces.

D. Test Bundle Return

1. Immediately upon completion of the test, return both the one-wash test piece(s) and the five-wash test piece(s) with all cut off numbers in a plastic bag to protect against damage, to the following address:

Mr. C. W. Ferguson
School of Textile Engineering
Georgia Institute of Technology
Atlanta, Georgia 30332

2. Fill out the accompanying report sheet and return with the test bundle(s). In the space after Comment, report any errors or problems encountered; i.e., "stained accidentally by stray colored shop towel" or "bundle accidentally tumble dried between washings".

3. Complete the laundering and return of the test bundle(s) without delay. This will avoid loss or distortion of results through aging.

REPORT SHEET

OPERATION	FORMULATION	WATER LEVEL	SUPPLIES
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

DESCRIPTIONS OF ITEMS:

COMMENTS:

APPENDIX C

PROCESSING INSTRUCTIONS

EXPERIMENTAL TEST BUNDLE PROGRAM

A number of test bundles (depending upon the number assigned to your plant) are enclosed with instructions in the test bundle bag. Each test bundle consists of a one-wash test piece and a five-wash test piece. Each test bundle is to be processed according to the classification(s) in the accompanying letter.

READ THESE INSTRUCTIONS COMPLETELY BEFORE PROCEEDING WITH PROCESSING !

The one-wash (small assembly) and five-wash (large assembly) are identified.

A. Preparation and Marking

1. Using a laundry marking pen or a marking machine, describe formula and items in load next to serial number on test piece.

   Note: If a test bundle is laundered with a colored industrial load for an example mark the bundle "industrial - shirts - colored"; or if laundered with sheets mark the bundle "light - sheets".

2. Do not wash any test piece in a net. You may attach the test bundle to the outside of a net.

B. Laundering Instructions for a One-Wash Test Piece (small assembly)

1. The one-wash test piece and five-wash test piece must be washed in the same classification.

2. Wash the one-wash test piece once.

3. While it is unnecessary to extract the test bundle following laundering, if extraction with the load is more convenient, the test bundle will not be affected.

4. DO NOT PRESS, IRON, OR TUMBLE-DRY. ALLOW TEST PIECE TO AIR-DRY. RETAIN FOR RETURN TO THE LABORATORY.

   NOTE: The test piece may be laid out on a clean towel; smooth out by hand to remove wrinkles. Avoid contact with dust, lint, or metal surfaces.

C. Laundering Instructions for Five-Wash Test Piece (large assembly)

1. The one-wash test piece and five-wash test piece must be washed in the same classification.

2. Wash the five-wash test piece five times.

3. After each washing, cut off the lowest number from the numbered strip attached to the test piece and place in plastic bag for return to Laboratory.

4. Keep test piece in a separate plastic bag between washing cycles to avoid contamination.

5. It is unnecessary to extract the test piece between washings. If extraction with the load is more convenient, this will not affect the test piece.

6. DO NOT PRESS, IRON, OR TUMBLE-DRY. ALLOW TEST PIECE TO AIR-DRY. RETAIN FOR RETURN TO THE LABORATORY.

   NOTE: The test piece may be laid out on a clean towel; smooth out by hand to remove wrinkles. Avoid contact with dust, lint or metallic surfaces.

D. Return of Test Bundle and Report Form

1. Immediately upon completion of the test, return both the one-wash test piece(s) and the five-wash test piece(s) with all cut off numbers in a plastic bag to protect against damage, to the following address:

   Mr. C. W. Ferguson
   School of Textile Engineering
   Georgia Institute of Technology
   Atlanta, Georgia 30332

2. Fill out the accompanying report sheet and return with the test bundle(s). In the space after Comment, report any errors or problems encountered; i.e., "stained accidentally by stray colored shop towel" or "bundle accidentally tumble dried between washings".

3. Complete the laundering and return of the test bundle(s) without delay. This will avoid loss or distortion of results through aging.

REPORT SHEET - COMPLETE AND RETURN THIS REPORT WITH BUNDLE

PLANT NAME ______________________ DATE ______________________

BUNDLE #	WASHER, MAKE, TYPE, & SIZE	LOAD WT.	LOAD DESCRIPTION (Type of Formula, Item, and Color)

OPERATION	TIME (Min.)	TEMP. °F.	WATER LEVEL (inches)	SUPPLIES - TYPE AND QUANTITY PER LOAD
1				
2				
3				
4				

COMMENTS: (Describe any irregular conditions which occur during processing. For example: shop towel in white load, etc. Use other side if necessary.)

APPENDIX D

Participants In National Test Program

Institute of Industrial Launderers

Carolina Uniform Service, Inc.

Clean Coverall Supply Co.

Coverall Rental Service, Inc.

Penn Overall Supply Co.

Carter Industrial Laundry, Inc.

Kovakar Company

F. W. Means and Co.

Standard Overall Service, Inc.

Linen Supply Association of America

The Independent Towel Supply Co.

American Linen Supply (Minnesota)

Wayne Towel and Linen Supply Co.

American Linen Supply (California)

Standard Coat, Apron, and Linen Service

APPENDIX E

Testor Number : 20

Plant Type : Industrial

Soil Classification : Colored Formula

Washer Type : Zephyr 660#

Washing Factors

	One Wash	Five Wash
Bleaching intensity	——	——
Bleaching pH	——	——
Heat effects	O.K. but high	Too high
Alkali effects	Too high	Too high
Fatty soil removal	O.K. but high	O.K. but high
Mechanical action	O.K.	Too high
Oily stain removal	O.K. but low	O.K.
Whiteness	——	——
% tensile loss	——	11.8
% carbon removal	86.6	97.1
% fat removal	85.9	96.8
% oil removal	64.5	80.4

APPENDIX E Contd.

Testor Number : 3

Plant Type : Industrial

Soil Classification : White Formula

Washer Type : 1 3 4 Ludell 450 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	Too high	Too high
Bleaching pH	O.K. but high	Too high
Heat effects	O.K.	Too high
Alkali effects	O.K.	O.K.
Fatty soil removal	Too high	Too high
Mechanical action	O.K.	O.K.
Oily stain removal	O.K.	O.K.
Whiteness	2.20	2.15
% tensile loss	——	18.3
% carbon removal	51.6	93.5
% fat removal	45.2	82.6
% oil removal	58.9	77.0

Testor Number: 2

Plant Type: Industrial

Soil Classification : Colored Formula

Washer Type : 1 3 4 Ludell 440#

Washing Factors

	One Wash	Five Wash
Bleaching intensity	——	——
Bleaching pH	——	——
Heat effects	O. K. but high	O. K. but high
Alkali effects	O. K.	O. K. but high
Fatty soil removal	O. K.	O. K. but high
Mechanical action	O. K.	O. K.
Oily stain removal	O. K. but low	O. K.
Whiteness	——	——
% tensile loss	——	7.4
% carbon removal	68.0	91.9
% fat removal	43.3	86.3
% oil removal	58.0	81.2

APPENDIX E Contd.

Testor Number : 4

Plant Type : Industrial

Soil Classification : White Formula

Washer Type : Ellis Dump 800 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K.	Too high
Bleaching pH	O.K. but high	Too high
Heat effects	Too high	Too high
Alkali effects	O.K. but high	O.K. but high
Fatty soil removal	O.K. but high	Too high
Mechanical action	O.K.	O.K. but high
Oily stain removal	O.K. but low	O.K.
Whiteness	2.50	2.52
% tensile loss	_____	10.6
% carbon removal	81.0	95.5
% fat removal	81.6	91.9
% oil removal	94.0	97.8

APPENDIX E Contd.

Testor Number : 5

Plant Type : Industrial

Soil Classification : Colored Formula

Washer Type

Washing Factors

	One Wash	Five Wash
Bleaching intensity	———	———
Bleaching pH	———	———
Heat effects	O.K.	O.K. but high
Alkali effects	O.K.	O.K.
Fatty soil removal	O.K. but high	O.K. but high
Mechanical action	O.K.	O.K.
Oily stain removal	O.K. but low	O.K. but low
Whiteness	———	———
% tensile loss	———	12.8
% carbon removal	82.4	94.2
% fat removal	79.4	93.9
% oil removal	94.3	98.4

APPENDIX E Contd.

Testor Number : 6

Plant Type : Industrial

Soil Classification : Colored Formula

Washer Type : Cumming and Landau 800#

Washing Factors

	One Wash	Five Wash
Bleaching intensity	----	----
Bleaching pH	----	----
Heat effects	O.K. but low	Too high
Alkali effects	O.K. but low	O.K.
Fatty soil removal	O.K.	O.K. but high
Mechanical action	Too low	O.K.
Oily stain removal	O.K.	O.K.
Whiteness	----	----
% tensile loss	----	18.6
% carbon removal	85.4	90.7
% fat removal	33.1	82 6
% oil removal	49.6	84.7

Testor Number : 7

Plant Type : Industrial

Soil Classification : White Formula

Washer Type : Cumming and Landau 800 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K.	Too high
Bleaching pH	O.K.	O.K. but high
Heat effects	Too high	Too high
Alkali effects	O.K.	O.K.
Fatty soil removal	O.K. but high	Too high
Mechanical action	O.K.	O.K.
Oily stain removal	O.K.	O.K.
Whiteness	2.56	2.42
% tensile loss	——	16.5
% carbon removal	79.6	94.0
% fat removal	53.1	93.6
% oil removal	70.1	86.8

Testor Number : 8

Plant Type : Industrial

Soil Classification : White Formula

Washer Type : Miller Open - End 400 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K. but low	O.K. but low
Bleaching pH	O.K.	O.K.
Heat effects	O.K. but high	O.K. but high
Alkali effects	Too high	O.K. but high
Fatty soil removal	O.K. but high	O.K. but high
Mechanical action	O.K.	O.K.
Oily stain removal	O.K.	O.K.
Whiteness	2.20	2.09
% tensile loss	———	6.3
% carbon removal	85.0	81.0
% fat removal	84.5	88.2
% oil removal	76.7	74.8

APPENDIX E Contd.

Testor Number : 9

Plant Type : Industrial

Soil Classification : Colored Formula

Washer Type : Miller Open-End 400#

Washing Factors

	One Wash	Five Wash
Bleaching intensity	—	—
Bleaching pH	—	—
Heat effects	O.K. but high	O.K. but high
Alkali effects	Too high	Too high
Fatty soil removal	O.K. but high	O.K. but high
Mechanical action	O.K.	O.K.
Oily stain removal	O.K.	O.K.
Whiteness	—	—
% tensile loss	—	5.0
% carbon removal	89.3	88.9
% fat removal	88.1	85.8
% oil removal	79.3	77.8

APPENDIX E Contd.

Testor Number : 11

Plant Type : Industrial

Soil Classification : White Formula

Washer Type

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K.	O.K.
Bleaching pH	O.K.	O.K.
Heat effects	Too high	Too high
Alkali effects	Too high	Too high
Fatty soil removal	O.K. but high	Too high
Mechanical action	O.K.	O.K.
Oily stain removal	O.K.	O.K.
Whiteness	2.56	2.47
% tensile loss	———	17.0
% carbon removal	88.7	98.0
% fat removal	86.4	96.0
% oil removal	61.7	79.0

APPENDIX E Contd.

Testor Number : 10

Plant Type : Industrial

Soil Classification : Colored Formula

Washer Type

Washing Factors

	One Wash	Five Wash
Bleaching intensity	———	———
Bleaching pH	———	———
Heat effects	Too high	Too high
Alkali effects	Too high	Too high
Fatty soil removal	O.K. but high	Too high
Mechanical action	O.K. but high	O.K. but high
Oily stain removal	O.K.	O.K.
Whiteness	——	——
% tensile loss	——	10.1
% carbon removal	84.3	98.4
% fat removal	85.7	97.3
% oil removal	52.7	81.8

APPENDIX E Contd.

Testor Number : 13

Plant Type : Industrial

Soil Classification : White Formula

Washer Type : Cumming and Landau 900 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K.	Too high
Bleaching pH	O.K. but low	Too high
Heat effects	O.K.	Too high
Alkali effects	O.K.	O.K.
Fatty soil removal	O.K.	Too high
Mechanical action	O.K. but low	O.K. but low
Oily stain removal	O.K. but low	O.K.
Whiteness	2.57	2.60
% tensile loss	———	16.2
% carbon removal	77.0	90.3
% fat removal	59.4	95.3
% oil removal	48.8	88.7

Testor Number : 12

Plant Type : Industrial

Soil Classification : Colored Formula

Washer Type : Cumming and Landau 1200

Washing Factors

	One Wash	Five Wash
Bleaching intensity	——	——
Bleaching pH	——	——
Heat effects	Too high	Too high
Alkali effects	O.K.	O.K. but high
Fatty soil removal	O.K.	Too high
Mechanical action	O.K.	O.K. but high
Oily stain removal	O.K.	O.K.
Whiteness	——	——
% tensile loss	——	12.8
% carbon removal	——	82.0
% fat removal	——	93.3
% oil removal	——	88.5

Testor Number : 15

Plant Type : Industrial

Soil Classification : White Formula

Washer Type : Miller Open - End 350 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	Too high	Too high
Bleaching pH	O.K. but low	Too high
Heat effects	Too high	Too high
Alkali effects	O.K.	Too high
Fatty soil removal	Too high	Too high
Mechanical action	O.K.	O.K.
Oily stain removal	O.K. but low	O.K. but low
Whiteness	2.51	2.36
% tensile loss	———	29.4
% carbon removal	90.1	97.7
% fat removal	76.5	96.1
% oil removal	79.5	86.9

Testor Number : 14

Plant Type : Industrial

Soil Classification : Colored Formula

Washer Type :Miller Open-End 400 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	———	———
Bleaching pH	———	———
Heat effects	O.K.	Too high
Alkali effects	Too high	Too high
Fatty soil removal	O.K.	O.K. but high
Mechanical action	O.K. but low	O.K. but low
Oily stain removal	Too low	Too low
Whiteness	——	——
% tensile loss	——	14.8
% carbon removal	——	57.1
% fat removal	——	20.0
% oil removal	——	16.4

APPENDIX E Contd.

Testor Number : 19

Plant Type : Linen

Soil Classification : Light soil

Washer Type

Washing Factors

	One Wash	Five Wash
Bleaching intensity	Too high	Too high
Bleaching pH	O.K.	O.K. but high
Heat effects	O.K.	O.K.
Alkali effects	O.K.	O.K.
Fatty soil removal	O.K.	Too high
Mechanical action	O.K.	O.K.
Oily stain removal	O.K.	O.K.
Whiteness	2.49	2.64
% tensile loss	____	12.2
% carbon removal	69.1	88.1
% fat removal	62.1	82.7
% oil removal	29.8	60.6

APPENDIX E Contd.

Testor Number : 21

Plant Type: Linen

Soil Classification : Medium soil

Washer Type

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K. but high	O.K. but high
Bleaching pH	Too high	Too high
Heat effects	Too high	Too high
Alkali effects	Too high	Too high
Fatty soil removal	Too high	Too high
Mechanical action	O.K.	O.K.
Oily stain removal	Too high	Too high
Whiteness	2.60	2.54
% tensile loss	____	20.8
% carbon removal	83.1	96.8
% fat removal	79.2	91.3
% oil removal	59.0	74.2

Testor Number : 22

Plant Type : Linen

Soil Classification : Heavy soil

Washer Type

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K. but low	O.K.
Bleaching pH	O.K.	O.K.
Heat effects	Too high	Too high
Alkali effects	Too high	Too high
Fatty soil removal	O.K.	Too high
Mechanical action	O.K. but low	O.K. but low
Oily stain removal	O.K.	O.K.
Whiteness	2.57	2.49
% tensile loss	——	22.4
% carbon removal	79.6	92.0
% fat removal	87.6	94.2
% oil removal	70.1	76.3

APPENDIX E Contd.

Testor Number : 24

Plant Type : Linen

Soil Classification : Light soil

Washer Type : Ellis 900 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K.	O.K.
Bleaching pH	O.K.	O.K. but high
Heat effects	Too high	Too high
Alkali effects	O.K.	O.K.
Fatty soil removal	O.K.	O.K.
Mechanical action	O.K.	O.K.
Oily stain removal	O.K.	O.K.
Whiteness	2.50	2.44
% tensile loss	———	15.3
% carbon removal	45.3	40.6
% fat removal	34.7	74.8
% oil removal	46.9	78.0

APPENDIX E Contd.

Testor Number : 25

Plant Type : Linen

Soil Classification : Medium soil

Washer Type : Ellis 1000 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K. but low	O.K.
Bleaching pH	O.K. but low	O.K. but high
Heat effects	Too high	Too high
Alkali effects	O.K.	O.K.
Fatty soil removal	O.K.	O.K.
Mechanical action	O.K.	O.K.
Oily stain removal	O.K.	O.K.
Whiteness	2.43	2.57
% tensile loss	———	13.8
% carbon removal	58.6	57.6
% fat removal	33.4	66.5
% oil removal	53.6	72.2

APPENDIX E Contd.

Testor Number : 23

Plant Type : Linen

Soil Classification : Heavy

Washer Type : Ellis

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K.	O.K. but high
Bleaching pH	O.K.	O.K.
Heat effects	O.K. but high	Too high
Alkali effects	O.K.	Too high
Fatty soil removal	O.K. but high	Too high
Mechanical action	Too low	O.K.
Oily stain removal	Too low	O.K.
Whiteness	2.54	2.50
% tensile loss	———	19.5
% carbon removal	60.4	70.5
% fat removal	61.0	92.1
% oil removal	66.3	82.6

APPENDIX E Contd.

Testor Number : 36

Plant Type : Linen

Soil Classification : Light soil

Washer Type : Ellis 800 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	Too low	Too high
Bleaching pH	O.K. but low	O.K. but low
Heat effects	O.K. but low	O.K. but high
Alkali effects	Too low	Too high
Fatty soil removal	Too low	Too high
Mechanical action	O.K.	O.K.
Oily stain removal	O.K. but low	O.K.
Whiteness	2.54	2.58
% tensile loss	———	12.8
% carbon removal		84.5
% fat removal		89.0
% oil removal		67.9

APPENDIX E Contd.

Testor Number : 34

Plant Type : Linen

Soil Classification : Medium

Washer Type : Ellis 800 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K. but high	Too high
Bleaching pH	O.K.	Too high
Heat effects	O.K.	Too high
Alkali effects	Too low	O.K.
Fatty soil removal	O.K. but high	O.K. but high
Mechanical action	O.K.	O.K.
Oily stain removal	O.K.	O.K.
Whiteness	2.47	2.58
% tensile loss	——	12.1
% carbon removal	67.2	81.7
% fat removal	21.6	71.2
% oil removal	24.5	60.9

Testor Number : 35

Plant Type : Linen

Soil Classification : Heavy soil

Washer Type : Ellis 800 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K.	O.K.
Bleaching pH	O.K.	O.K. but high
Heat effects	O.K.	O.K.
Alkali effects	O.K.	O.K. but high
Fatty soil removal	O.K. but high	O.K. but high
Mechanical action	Too low	Too low
Oily stain removal	O.K.	O.K. but low
Whiteness	2.55	2.52
% tensile loss	———	21.7
% carbon removal		73.0
% fat removal		29.8
% oil removal		37.2

Testor Number : 40

Plant Type : Linen

Soil Classification : Light soil

Washer Type

Washing Factors

	One Wash	Five Wash
Bleaching intensity	Too high	Too high
Bleaching pH	O.K. but high	Too high
Heat effects	O.K.	O.K.
Alkali effects	O.K. but low	O.K.
Fatty soil removal	O.K.	Too high
Mechanical action	O.K.	O.K.
Oily stain removal	Too high	Too high
Whiteness	2.70	2.51
% tensile loss	———	22.1
% carbon removal	58.0	52.6
% fat removal	26.6	77.9
% oil removal	29.1	55.2

Testor Number : 41

Plant Type : Linen

Soil Classification : Medium soil

Washer Type

Washing Factors

	One Wash	Five Wash
Bleaching intensity	O.K.	Too high
Bleaching pH	O.K.	Too high
Heat effects	O.K.	O.K.
Alkali effects	O.K.	Too high
Fatty soil removal	O.K.	Too high
Mechanical action	O.K.	O.K.
Oily stain removal	O.K. but high	O.K. but high
Whiteness	2.51	2.51
% tensile loss	———	27.0
% carbon removal	80.9	86.5
% fat removal	48.6	73.3
% oil removal	48.2	59.2

APPENDIX E Contd.

Testor Number : 42

Plant Type : Linen

Soil Classification : Heavy soil

Washer Type

Washing Factors

	One Wash	Five Wash
Bleaching intensity	Too high	Too high
Bleaching pH	Too high	Too high
Heat effects	O.K. but low	O.K. but low
Alkali effects	O.K.	Too high
Fatty soil removal	Too high	Too high
Mechanical action	O.K. but low	O.K. but low
Oily stain removal	O.K.	O.K.
Whiteness	2.56	2.46
% tensile loss	———	25.5
% carbon removal	78.9	87.5
% fat removal	75.2	90.5
% oil removal	63.7	71.8

Testor Number : 28

Plant Type : Linen

Soil Classification : Medium soil

Washer Type : 1200 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	Too high	O.K. but high
Bleaching pH	O.K. but high	Too high
Heat effects	O.K. but high	O.K. but high
Alkali effects	Too high	Too high
Fatty soil removal	Too high	Too high
Mechanical action	O.K.	O.K.
Oily stain removal	O.K.	O.K.
Whiteness	2.60	2.53
% tensile loss	——	24.9
% carbon removal	76.1	84.9
% fat removal	92.0	96.6
% oil removal	55.4	78.6

Testor Number : 29

Plant Type : Linen

Soil Classification : Heavy soil

Washer Type : Ellis 800 #

Washing Factors

	One Wash	Five Wash
Bleaching intensity	Too high	Too high
Bleaching pH	O.K. but high	Too high
Heat effects	O.K. but high	Too high
Alkali effects	O.K.	Too high
Fatty soil removal	O.K. but high	Too high
Mechanical action	O.K. but low	O.K.
Oily stain removal	O.K.	O.K.
Whiteness	2.61	2.49
% tensile loss	———	20.1
% carbon removal	82.4	92.7
% fat removal	64.6	94.7
% oil removal	64.9	76.6